LTMO Case Study
Army Installation in Pacific Northwest

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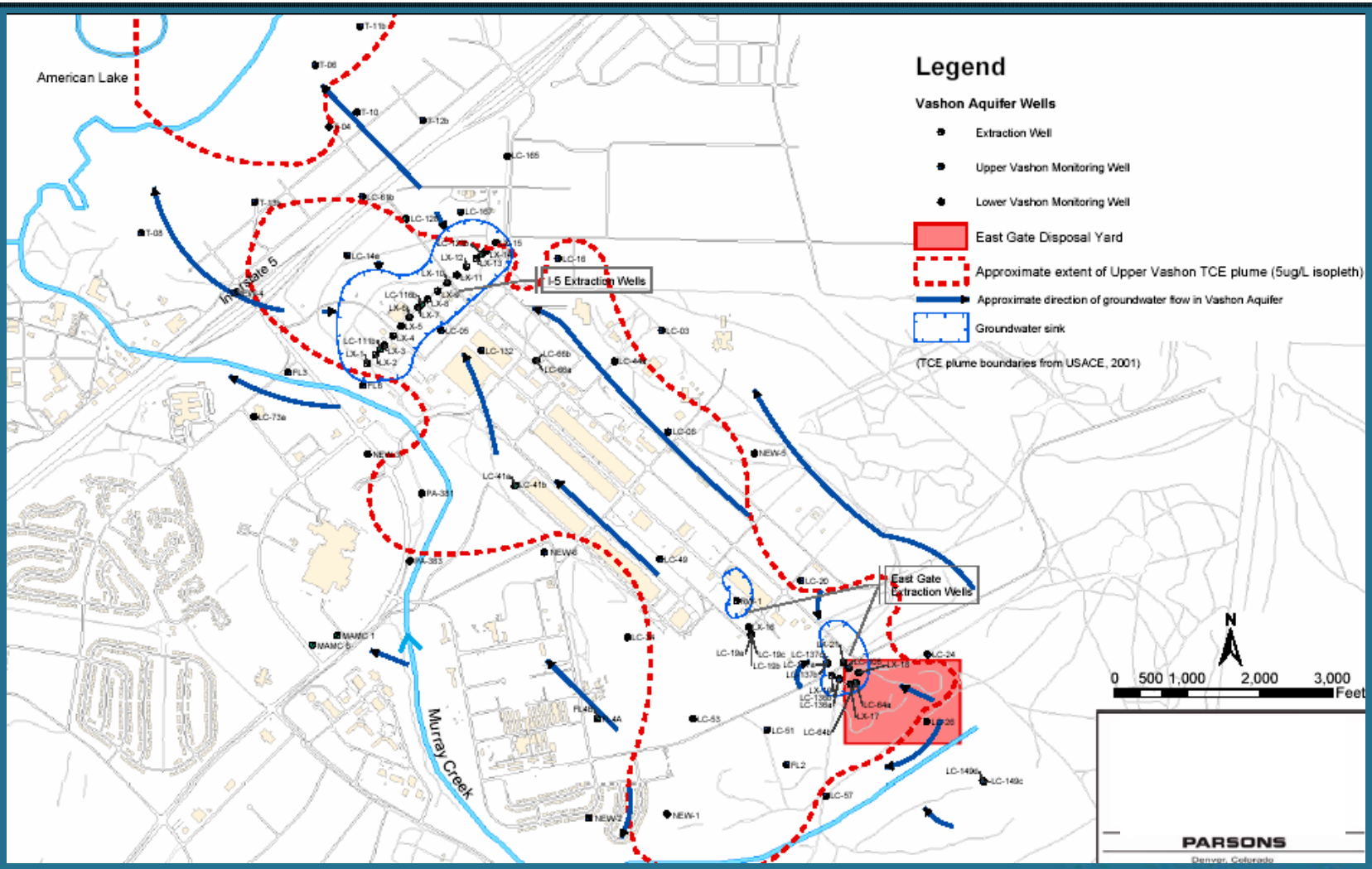
Background

- Large Pump & Treat System, Army Installation, USACE Project
  - 2-Mile-Long TCE Plume from Dump Area (DNAPL)
  - Containment System at Boundary
  - Additional Wells Near Source
  - Hydrogeology – Outwash Sands, Gravels, Tills, Non-Glacial Deposits. Plume in Outwash
- ~ 40 Wells Had Been Sampled Quarterly
  - Some Background, Some in Source, Some in Middle of Plume, Some Near Boundary/Downgradient
  - Some Wells at Different Depths

Site Layout


American Lake
Interstate 5
I-5 Extraction Wells
East Gate Extraction Wells
Murray Creek
Legend
Vashon Aquifer Wells
Extraction Well
Upper Vashon Monitoring Well
Lower Vashon Monitoring Well
East Gate Disposal Yard
Approximate extent of Upper Vashon TCE plume (5ug/L isopleth)
Approximate direction of groundwater flow in Vashon Aquifer
Groundwater sink
(TCE plume boundaries from USACE, 2001)
N
0 500 1,000 2,000 3,000
Feet
PARSONS
Denver, Colorado

Previous Analyses of Monitoring Program

- Program: Quarterly Sampling of ~40 Wells
- Optimization Recommended in 1999 Remediation System Evaluation
  - Professional Judgment Only
  - Recommended 3 Wells Removed from Network
  - Assessed Trends – Recommended Lower Frequency
  - RSE Recommended More Rigorous Analysis
- USACE District Used MAROS to Optimize, Removed Some Wells, Added Others in 2001
- Demonstration Project Applied Three-Tiered, MAROS

Results of Demonstration

Three-Tiered Approach – Qualitative Evaluation

- Recommended Removal of 15 Wells
- Reduced Frequency of 11 Other Wells
- Recommended Reduced Frequency for Sampling Extraction Wells to Annually
- Recommended Change in Analytical Method
- Revisit Monitoring if Change in Extraction System

Results of Demonstration

Three-Tiered Approach – Trend Analysis

- Plot Concentrations over Time for Monitoring Points
- Perform Statistical Tests for Trend
  - Mann-Kendall Test
  - Non-parametric
  - Specified Level of Confidence in Trend
  - Quantify Trend Line
- Different Recommendations Based on Trend & Location
  - Increasing Trend: Retain if Not in Source Area
  - Decreasing Trend: Retain if in Source Area or Sentinel Well
  - No Trend: Retain if Sentinel Well or if Variability High
  - Non-Detect: Retain if Sentinel Well Only
- Recommended Removal of 20 Wells

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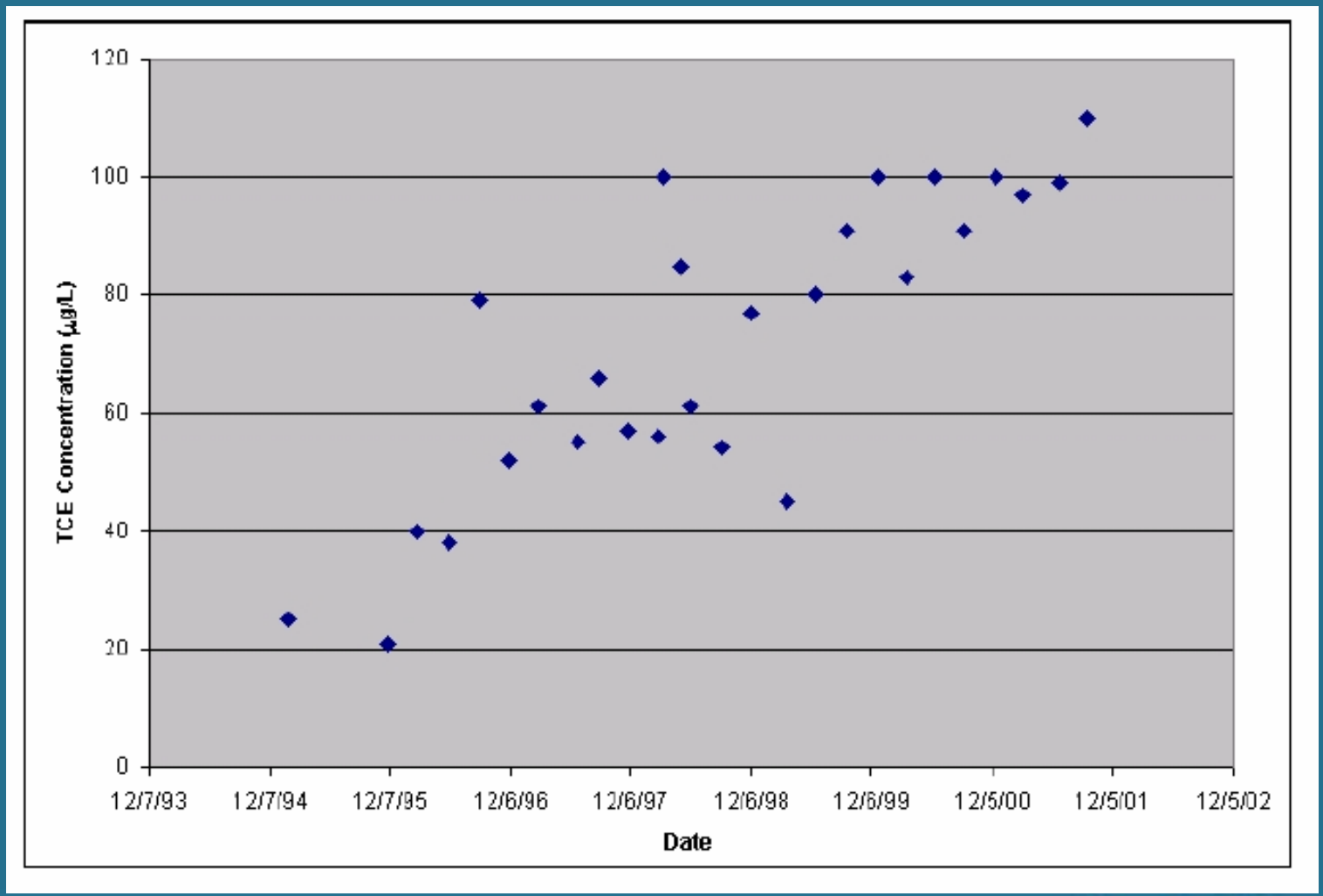
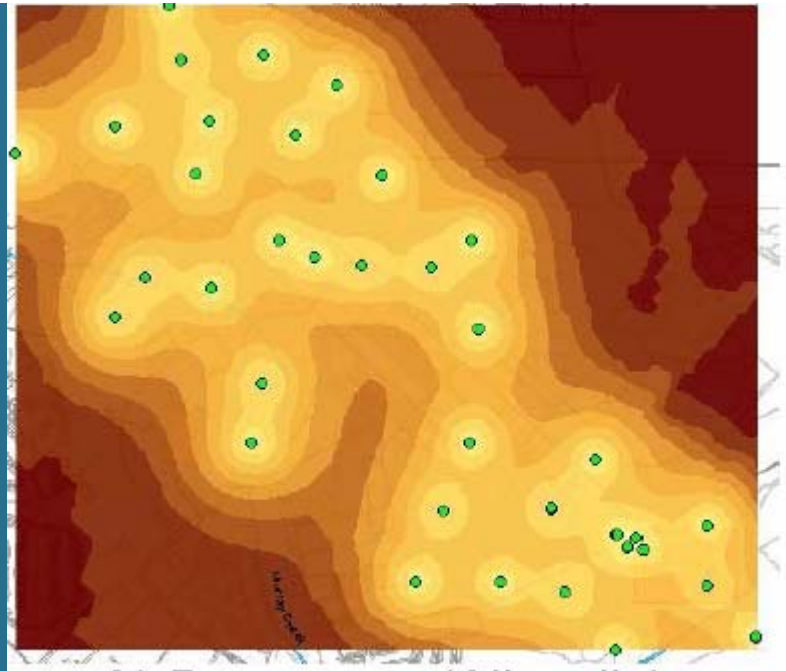
Trend for One Monitoring Well



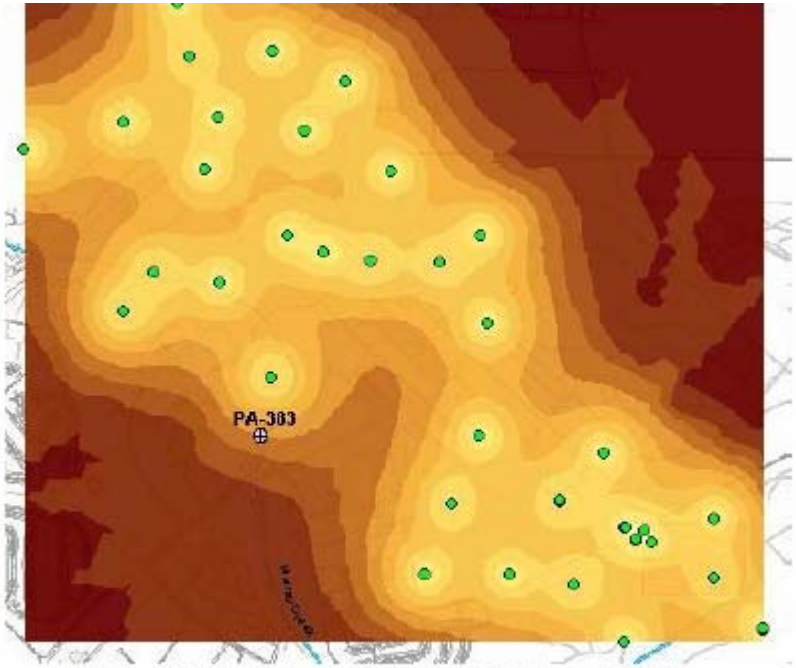
Results of Demonstration

Three-Tiered Approach – Spatial Network Analysis

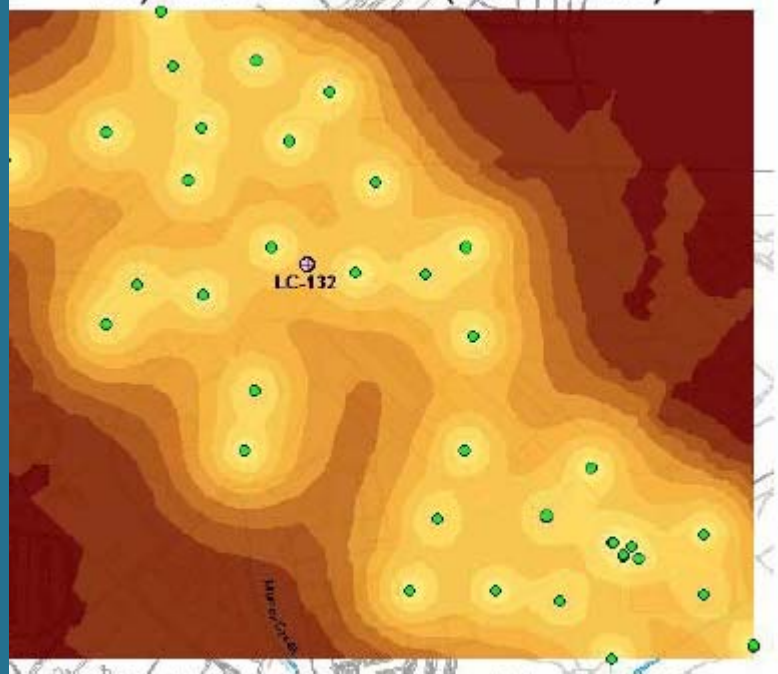
- Evaluate Monitoring Network using Geostatistics
  - Develop Variograms, Model
  - Krige Iteratively Using All but One Well
  - Look at Median Prediction Errors vs. Base Case (with All Wells)
  - Rank Wells Based on Error Increase if Excluded
- Recommended Removal of 21 Wells
- Recommended Adjustment of Some Proposed New Wells in Areas of High Error



A) Base-case (All wells)



B) "Missing" Well PA-383



C) "Missing" Well LC-132

Legend

Well missing from kriging realization

Prediction Standard Error Map

Less spatial uncertainty

Greater spatial uncertainty

FIGURE 6.2
IMPACT OF MISSING WELLS ON PREDICTED STANDARD ERROR
Monitoring Network Optimization

PARSONS
Denver, Colorado

Results of Demonstration

Three-Tiered Approach – Overall Analysis

- Professionals Reviewed Results of Three Analyses and Combined into Recommendation
- Overall Recommendation:
  - Remove 13 Wells, Add One
  - Relative to Original Quarterly Sampling - Reduce Frequency: 7 Semi-Annually, 17 Annually, 14 Biennially (16 to Stay Quarterly), Reduce Sampling of Extraction Wells
  - Many of These Changes Made in 2001 Evaluation
  - However, Still Reduce Number of Samples from 180 to 107/year Compared to Current (Revised 2001) Program

Results of Demonstration

MAROS Analysis

- Based on Mann-Kendall Trend Analysis, Plume is Relatively Stable, Requiring Only Moderate Sampling Intensity (semiannual or less frequent)
- Well Redundancy Analysis
  - Delaunay Approach Similar to Geostatistics, but Simpler Based on Slopes between Lines Connect
  - Delaunay Triangle Analysis Indicated Could Remove 8 Wells, but Would Recommend Adding 6 Others

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Results of Demonstration

MAROS Analysis, Continued

- Sample Frequency Using Modified CES Approach:
  - 56% Less Samples per Year Relative to Original Quarterly Sampling, But Similar to 2001 Revision to Program

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Net Result

- Save **$34,000 to $36,000 / Year**